UNIVERSITY OF DEBRECEN, FACULTY OF INFORMATICS

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COMPUTER SCIENCE BSC

2021

Mode: Full-time training

Program Coordinator: Dr. Márton Ispány (ispany.marton@inf.unideb.hu)

Mentor: Dr. Péter Jeszenszky (jeszenszky.peter@inf.unideb.hu)

Qualification requirements

General requirements of the diploma are regulated by The Rules and Regulations of The University of Debrecen.

Work and Fire Safety and Physical Education

The courses of „Work and Fire Safety" and „Physical Education" are worth 1 - 1 credit, which must be completed in excess of the number of credits required for the diploma as specified in the training and outcome requirements of the degree.

Diploma credit requirements

Matematics and Computer Science:		60 credits
Informatics:		90 credits
Compulsory topics:	54 credits	
Differentiated knowledge topics:	36 credits	
Professional Training:	12 credits	
Thesis work:		20 credits
Free choise subjects:		10 credits
Total:		**180 credits**
Work and Fire Safety:		1 credit
Physical Education (2 semesters):		2 credits

Mathematics and Computer Science – needed 60 credits

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INBPA0101-21 INBPA0101E INBPA0101G	Logic in computer science	6	2	2		E S		1	1
INBPA0102-17 INBPA0102E INBPA0102G	Discrete mathematics	6	2	2		PM		1	1
INBPA0103-17 INBPA0103E INBPA0103L	Computer aided mathematics and visualization	6	2		2	PM		1	1
INBPA0206-17 INBPA0206E INBPA0206G	Data structures and algorithms	6	2	2		E S	INBPA0101-21 INBPA0102-17	2	2
INBPA0207-21 INBPA0207E INBPA0207G	Calculus	6	2	2		PM		2	2
INBPA0313-17 INBPA0313E INBPA0313L	Applied statistics	6	2		2	E S	INBPA0207-21	1	3
INBPA0314-21 INBPA0314E INBPA0314G	Introduction to computer science	6	2	2		E S	INBPA0102-17	1	3
INBPA0417-21 INBPA0417G INBPA0417L	Applied mathematics	6		2	2	PM	INBPA0102-17	2	4
INBPA0418-21 INBPA0418E INBPA0418L	Foundations of artificial intelligence	6	2		2	E S	INBPA0101-21 INBPA0211-21	2	4
INBPA0419-17 INBPA0419E INBPA0419L	Foundations of computer security	6	2		2	E S	INBPA0211-21	2	4

Informatics (Compulsory topics) – needed 54 credits

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INBPA0104-21 NBPA0104L	Introduction to programming	3			2	PM		1	1
INBPA0105-21 INBPA0105E INBPA0105L	Operating systems	6	2		2	E S		1	1
INBPA0208-17 INBPA0208E	Database systems	3	2			E	INBPA0101-21	2	2
INBPA0209-17 INBPA0209L	Database systems lab	3			2	PM	INBPA0101-21	2	2
INBPA0210-17 INBPA0210E INBPA0210L	Network architectures and protocols	6	2		2	E S	INBPA0104-21 INBPA0105-21	2	2
INBPA0211-21 INBPA0211E INBPA0211L	High-level programming languages 1	6	2		2	E S	INBPA0104-21	2	2

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INBPA0315-21 INBPA0315G INBPA0315L	High-level programming languages 2	6		2	2	PM	INBPA0211-21	1	3
INBPA0316-17 INBPA0316E INBPA0316L	Web technologies	6	2		2	E S	INBPA0104-21	1	3
INBPA0420-21 INBPA0420E INBPA0420L	Software engineering and technologies	6	2		2	PM	INBPA0315-21	2	4
INBPA0521-17 INBPA0521L	Software development methodologies	3			2	PM	INBPA0211-21	1	5
INBPA0522-21 INBPA0522G INBPA0522L	Web application development	6		2	2	PM	INBPA0315-21 INBPA0316-17	1	5

Thesis work – needed 20 credits

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	gyakorlat					
				tant.	labor				
INBPA0523-21 INBPA0523X	Thesis 1	5				PM		1	5
INBPA0623-21 INBPA0623X	Thesis 2	15				PM		2	6

Informatics (Differentiated knowledge topics) – needed 36 credits

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INBPA9924-17 INBPA9924L	3D printing and modeling	3			2	PM	INBPA0103-17	2	2
INBPA9925-17 INBPA9925L	Cloud computing	3			2	PM	INBPA0105-21	2	2
INBPA9926-17 INBPA9926L	Basics of GIS	3			2	PM	INBPA0103-17	2	2
INBPA9944-17 INBPA9944L	Graphics Systems	3			2	PM	INBPA0103-17	2	2
INBPA9927-17 INBPA9927L	Bioinformatics	3			2	PM	INBPA0206-17	1	3
INBPA9928-21 INBPA9928E	E-Sport	3	2			E	INBPA0211-21	1	3
INBPA9929-17 INBPA9929E INBPA9929L	Operation of infocommunication systems	6	2		2	PM	INBPA0210-17	1	3
INBPA9930-17 INBPA9930L	Image processing in practice	3			2	PM	INBPA0211-21	1	3
INBPA9931-17 INBPA9931L	High-level programming languages 3	3			2	PM	INBPA0211-21	1	3

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INBPA9942-17 INBPA9942L	Scripting Languages	3			2	PM	INBPA0211-21	1	3
INBPA9932-17 INBPA9932L	Introduction to 3D game development	3			2	PM	INBPA0103-17 INBPA0315-21	2	4
INBPA9933-17 INBPA9933L	Compilers	3			2	PM	INBPA0211-21 INBPA0314-21	2	4
INBPA9934-17 INBPA9934L	Machine learning in practice	3			2	PM	INBPA0211-21 INBPA0313-17	2	4
INBPA9935-17 INBPA9935L	Advanced database knowledge	3			2	PM	INBPA0209-17	2	4
INBPA9936-17 INBPA9936L	NoSQL databases	3			2	PM	INBPA0209-17 INBPA0315-21	2	4
INBPA9943-17 INBPA9936E	Fundamentals of Information and Coding Theory	3	2			E	INBPA0313-17	2	4
INBPA9937-17 INBPA9937L	Mobile application development	3			2	PM	INBPA0420-21	1	5
INBPA9938-17 INBPA9938L	Computer Statistics	3			2	PM	INBPA0313-17	1	5
INBPA9939-17 INBPA9939L	Software testing	3			2	PM	INBPA0420-21	1	5
INBPA9940-17 INBPA9940L	Advanced data security	3			2	PM	INBPA0419-17 INBPA0522-21	2	6
INBPA9941-17 INBPA9941L	Advanced web technologies	3			2	PM	INBPA0522-21	2	6
INBPA9949-17 INBPA9949L	Virtual reality and its applications	3			2	PM	INBPA0103-17	I	
INBPA9950-17 INBPA9950L	Ethical hacking I.	3			2	PM	INBPA0211-21	I	
INBPA9951-17 INBPA9951E	Blockhain technology	3	2			E		I	
INBPA9955-17 INBPA9955L	Introduction to reinforcement learning	3			2	PM		I	
INBPA9958-17 INBPA9958L	Introduction to the AWS Cloud	3			2	PM		I	
INBPA9997-21 INBPA9997G	Professional Training	12				PM	INBPA0315-21 INBPA0208-17 INBPA0209-17	I	6

Free choice – needed 10 credits

Code	Subject name	Credit	Type and number			Assessment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				

Exam types:
E exam
S signature
PM practical mark

COMPUTER SCIENCE BSC

Description of Subjects

Mathematics and Computer Science

LOGIC IN COMPUTER SCIENCE

INBPA0101-21

Semester: 1
Type: Lecture / Seminar
Number of Classes: 2+2+0
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: None
Responsible: Dr. György Vaszil

Topics:
Exploring the logical structure of statements. Formalization in propositional logic. The language of propositional logic, the inductive definition of formulas, basic elements of syntax. Unary and binary logical operations, truth tables. Concepts of semantics: interpretation, truth valuation in interpretations, satisfiability and validity, equivalent formulas. Consequences in propositional logic. The language of first-order logic: terms and formulas, syntax. Formalization in first-order logic. Free and bound occurrences of variables, renaming bound variables, congruent formulas. Concepts of semantics in first order logics: interpretation, variable assignment, valuation of terms and formulas. Satisfiability, validity, contradiction, equivalence in first-order logics. Conjunctive and disjunctive normal forms, prenex form. First-order consequences. Checking the correctness of reasoning. A simple logical calculus: derivations, soundness, completeness.

Compulsory/Recommended Readings:
- Mordechai Ben-Ari: Mathematical Logic for Computer Science, 3rd ed., Springer, 2012. ISBN 978-1-4471-4128-0.
- Michael Huth, Mark Ryan: Logic in Computer Science, Cambridge University Press, 2002. ISBN 0-521-54310-X.

DISCRETE MATHEMATICS

INBPA0102-17

Semester: 1
Type: Lecture / Seminar
Number of Classes: 2+2+0
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Bernadett Aradi

Topics:
Sets, relations, functions. Numbers, mathematical induction, recursions. Complex numbers, their algebraic and trigonometric forms, operations, roots of unity. Polynomials, fundamental theorem of algebra, division of polynomials, Horner's method. Basic notions of number theory: divisibility, prime numbers, congruences. Elements of combinatorics: permutations, ordered selections, combinations.
Binomial theorem and its applications. Cardinality of sets. Systems of linear equations. Gaussian elimination. The n-dimensional Euclidean space. Vector spaces (linear dependence, basis).
Matrices (operations, determinant, rank). Inverse of a matrix. Linear transformations.
Eigenvalue, eigenvector. Introduction to graph theory.

Compulsory/Recommended Readings:
- Steven J. Leon: Linear Algebra with Applications. Pearson, 2010.
- Seymour Lipschutz, Marc Lipson: Shaum outline of Theory and problems of discrete mathematics.

COMPUTER AIDED MATHEMATICS AND VISUALIZATION

INBPA0103-17

Semester: 1
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Roland Imre Kunkli

Topics:
Functions, relations, basic function types. Drawing function graphs with computer software, visualizing different function properties. Bivariate functions and the possibilities of the visualization of their graphs. Basic vector operations, multiplication of vectors. Introducing derivatives and integrals through interactive and illustrative visual examples. Implicit equations and parametric equation systems of curves and surfaces. Short review of other well-known techniques for visualizing surfaces. Equations and equation systems of lines and planes. Relationships among spatial objects, distance and angle measurement. Finite mathematical and geometrical problems, and their computer based solutions. Matrices (multiplication of matrices, inverse, determinant). Linear equation systems through a geometrical approach. Linear transformations, orthogonal and symmetric matrices. Interesting problems solved by using homogeneous coordinates.

Compulsory/Recommended Readings:
- Farin, Gerald and Hansford, Dianne: Practical Linear Algebra: A Geometry Toolbox (3rd Edition), A K Peters/CRC Press, 2013., ISBN: 978-1466579569
- Thomas, George B., Weir, Maurice D., Hass, Joel R.: Thomas' Calculus (13th Edition), Pearson, 2014., ISBN: 978-0321878960

DATA STRUCTURES AND ALGORITHMS

INBPA0206-17

Semester:	2
Type:	Lecture / Seminar
Number of Classes:	2+2+0
Credit:	6
Status:	Obligatory
Assessment:	Exam
Prerequisites:	INBPA0101-21 (Logic in computer science) and INBPA0102-17 (Discrete mathematics)
Responsible:	Dr. Géza Horváth

Topics:
The course covers commonly used data structures, the algorithms necessary to manipulate them, and introduces the basic concepts of algorithmic complexity. Topics include elementary data structures, searching, sorting; hash tables, trees, graphs; time complexity, parallel algorithms basics.

Compulsory/Recommended Readings:
- Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein: Introduction to Algorithms. Third Edition. The MIT Press, Cambridge, Massachusetts London, England, 2009
- Donald E. Knuth: The Art of Computer Programming, volume 1. Third edition, Addison-Wesley, 1997
- Donald E. Knuth: The Art of Computer Programming, volume 3. Second edition, Addison-Wesley, 1998
- Seymour Lipschutz: Data Structures, McGraw-Hill, 2014

CALCULUS

INBPA0207-21

Semester: 2
Type: Lecture / Seminar
Number of Classes: 2+2+0
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Eszter Novák-Gselmann

Topics:
Sequences and their properties. Continuity of real functions. Differentiation of functions, extrema, Taylor's expansion. Riemann integral of real functions. Applications of differential and integral calculus.

Compulsory/Recommended Readings:
- Serge Lang, A first course in calculus, Undergraduate Texts in Mathematics, Springer-Verlag, 2012.
- Serge Lang, Undergraduate analysis, Undergraduate Texts in Mathematics, Springer-Verlag, New York, 1997.
- Thomas' Calculus, Addison Wesley (11th edition, 2005), ISBN: 0-321-24335-8

APPLIED STATISTICS

INBPA0313-17

Semester: 3
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: INBPA0207-21 (Calculus)
Responsible: Dr. István Fazekas

Topics:
Statistical observations. Numerical and graphical characteristics of the sample. Fitting functions to observations (regression analysis). Randomness of observations. Event, relative frequency, probability.
Conditional probability, independence of events. Theorem of total probability, the Bayes theorem.
Discrete random variables. Binomial, hypergeometric, and Poisson distributions. Expectation and variance of discrete random variables. Applications. The general notion of random variables. Cumulative distribution function, probability density function. Expectation and variance. Uniform, exponential, normal distributions and their applications. Joint distributions. Correlation coefficient. Multivariate normal distribution. Laws of large numbers and the central limit theorem. Their visualizations and applications. Statistical estimators: unbiased and consistent estimators. Confidence intervals. Testing statistical hypotheses. The u- and the t-tests. Nonparametric tests. Regression analysis. Analysis of variance: one-way classification. Classifications: linear separation and clustering.

Compulsory/Recommended Readings:
- D.C. Montgomery, G. C. Runger: Applied Statistics and Probability for Engineers. Wiley, 2003.
- Dirk P. Kroese: A Short Introduction to Probability. University of Queensland.

INTRODUCTION TO COMPUTER SCIENCE

INBPA0314-21

Semester: 3
Type: Lecture / Seminar
Number of Classes: 2+2+0
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: INBPA0102-17 (Discrete mathematics)
Responsible: Dr. György Vaszil

Topics:
Basics of formal languages and automata theory. Operations on words and languages, generative grammars, generated languages. Chomsky hierarchy and language classes. Regular grammars, regular expressions, closure properties. Nondeterministic and deterministic finite automata. Push-down automata, Chomsky normal form, the Cocke-Younger-Kasami algorithm. Deterministic context-free languages, LL(k) and LR(k) parsers. Deterministic Turing machines, algorithm models, decidable and undecidable problems, time/space complexity. Nondeterministic Turing machines, the complexity classes P and NP.

Compulsory/Recommended Readings:
- Géza Horváth, Benedek Nagy, Formal Languages and Automata Theory, Typotex, 2014.
- John Martin: Introduction to Languages, and the Theory of Computation, 4th edition, McGraw-Hill, New York, NY, 2011.
- Michael Sipser: Introduction to the Theory of Computation, Thomson, 2006.

APPLIED MATHEMATICS

INBPA0417-21

Semester: 4
Type: Seminar / Laboratory
Number of Classes: 0+2+2
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: INBPA0102-17 (Discrete mathematics)
Responsible: Dr. Ágnes Éva Baran

Topics:
Floating point arithmetic, errors. Perturbed linear systems, condition numbers of matricies. Numerical solution of system of linear equations. Least square approximations. Interpolation (Lagrange, Hermite, spline). Numerical integration. Eigenvalue problems, sparse matrices. Numerical solution of nonlinear equations and system of nonlinear equations. Minimization of functions. Solving Linear Programming problems (graphical solution, simplex method, Two-Phase simplex method). Duality and sensitivity analysis. Transportation and assignement problems. Solving optimization problems.

Compulsory/Recommended Readings:
- Gisbert Stoyan, Agnes Baran, Elementary Numerical Mathematics for Programmers and Engineers, Birkhäuser, 2016, ISBN 978-3-319-44659-2
- W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery, Numerical Recipes, Cambridge UP, 2007 ISBN 978-0-521-88407-5
- Wayne L. Winston Operations Research: Applications and Algorithms, ISBN-13: 978-0534380588, ISBN-10: 0534380581

FOUNDATIONS OF ARTIFICIAL INTELLIGENCE

INBPA0418-21

Semester:	4
Type:	Lecture / Laboratory
Number of Classes:	2+0+2
Credit:	6
Status:	Obligatory
Assessment:	Exam
Prerequisites:	INBPA0101-21 (Logic in computer science) and INBPA0211-21 (High-level programming languages 1)
Responsible:	Dr. Balázs Harangi

Topics:
Problem representations, state-space representation, state-space graph, examples. Uninformed systematic search in state-space graphs. Heuristic search strategies. Constraint satisfaction problems. Two-player games, representation of the game, game tree. Winning strategy. Min-max procedure, the alpha-beta pruning procedure. Knowledge representation: categories, objects, actions, situations, events, reasoning. Probabilistic reasoning (Bayesian networks). Tools of machine learning: learning from examples, statistical learning, perceptrons, neural networks, deep learning

Compulsory/Recommended Readings:
- Peter Norvig, Stuart J. Russell: Artificial Intelligence: A Modern Approach, 3rd edition, Pearson Education Limited, 2013. ISBN 129-202-420-8.
- Pedro Domingos: The Master Algorithm, Basic Books; 1 edition, 2015

FOUNDATIONS OF COMPUTER SECURITY

INBPA0419-17

Semester: 4
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: INBPA0211-21 (High-level programming languages 1)
Responsible: Dr. Andrea Pintér-Huszti

Topics:
Computer security concepts. The CIA traid. Physical and infrastructure security. Malicious software, DOS, firewalls. Encryption schemes, Ceasar-, Vigenére-, substitution ciphers, OTP, DES, 3DES, AES, RSA. Digital signatures, PKI, Identification, authentication, authorization. The SSL/TLS protocol.

Compulsory/Recommended Readings:
- William Stallings: Computer Security, Principles and Practice, 3. edition, 2015. ISBN-13: 978-0133773927
- Douglas R. Stinson: Cryptography Theory and Practice, 3. edition, Chapman & Hall/CRC, 2006, ISBN-13 978-1-58488-508-5

Informatics (Compulsory topics)

INTRODUCTION TO PROGRAMMING

INBPA0104-21

Semester: 1
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Péter Jeszenszky

Topics:
The goal of the subject is to demonstrate what is programming and how computer programs are made. Presenting the basic concepts and constructs of programming it aims at building basic level programming skills. Building and developing problem-solving and algorithmic skills necessary for programming is also a key objective of the subject. The following main topics are covered using a high-level programming language that supports procedural programming (e.g., C, C++, Python, Java, C#):

- Types, literals
- Operators, expressions
- Variables, assignment
- Statements
- Control structures
- Basic data structures of the programming language of the course (e.g., arrays, lists)
- Functions
- Basic I/O
- Other basic features of the programming language of the course (e.g., pointers)
- Writing simple programs
- Steps of creating executable programs
- Errors and bugs, debugging
- Basic level use of developer tools (e.g., an integrated development environment)

Compulsory/Recommended Readings:

- Robert C. Seacord. Effective C: An Introduction to Professional C Programming. No Starch Press, 2020.
- Bjarne Stroustrup. Programming: Principles and Practice Using C++. 2nd ed. Addison-Wesley Professional, 2014.
- John V. Guttag. Introduction to Computation and Programming Using Python. 3rd ed. MIT Press, 2021.
- Eric Matthes. Python Crash Course: A Hands-On, Project-Based Introduction to Programming. 2nd ed. No Starch Press, 2019.

OPERATING SYSTEMS

INBPA0105-21

Semester: 1
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: None
Responsible: Dr. László Szathmáry

Topics:
Concepts, tasks, and components of an operating system. Classification of the operating systems. Historical overview. Hardware, architectures. The Unix and the Linux operating systems. Boot sequence of Linux. Files and file systems. Special files under Unix. Redirection. Unix file systems. The i-node table. Extended File System. Filesystem Hierarchy Standard, a.k.a. the Unix directory structure. Process management. Signals. Priority, priority handling. Scheduling. File systems on Microsoft platforms (FAT, FAT32). The NTFS file system. Mobile operating systems.

Compulsory/Recommended Readings:
- Abraham Silberschatz, Greg Gagne, Peter B. Galvin: Operating system concepts, John Wiley and Sons, 2011.
- Andrew S. Tanenbaum, Albert S. Woodhull: Operating Systems Design and Implementation (3rd Edition), 2013.
- Eric S. Raymond: The Art of UNIX Programming, 2003.

DATABASE SYSTEMS

INBPA0208-17

Semester: 2
Type: Lecture
Number of Classes: 2+0+0
Credit: 3
Status: Obligatory
Assessment: Exam
Prerequisites: INBPA0101-21 (Logic in computer science)
Responsible: Dr. Márton Ispány

Topics:
Basic concepts: database, database system, database management system. Features, languages, interfaces, users of the DBMSs. Data modelling, abstraction. Entity, attribute, relationship. Features of the attributes and relationships. The relational model: relation schema, relation, integrity constraints.
The abstract query languages of the relaional model. Functional dependency and its features. Basics of relational database design: normalization, normal forms (1NF, 2NF, 3NF). Higher normal forms (BCNF, 4NF, 5NF). Multivalued and join dependency. The entity-relationship model. Mapping the entity-relationship model into relational data model. The enhanded entity-relationship model. Mapping the enhanced entity-relationship model into relational data model. Object-relational databases, Transaction, privileges and concurency controll, Data warehouses, NoSQL databases, Basics of Big Data, visualization, Basics of database administration and tuning.

Compulsory/Recommended Readings:
- Ramez Elmasri, Shamkant B. Navathe: Fundamentals of Database Systems (7th Edition), Pearson, 2015.
- Nenad Jukic, Susan Vrbsky, Svetlozar Nestorov: Database Systems: Introduction to Databases and Data Warehouses, Prospect Press, 2016.

DATABASE SYSTEMS LAB

INBPA0209-17

Semester: 2
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Obligatory
Assessment: Practical mark
Prerequisites: INBPA0101-21 (Logic in computer science)
Responsible: Dr. Márton Ispány

Topics:
With using the selected relational database management system using and getting acuainted with the followings: SELECT statement and its parts (ORDER BY, WHERE, GROUP BY, grouping functions, HAVING, JOINs, subqueries, set operations). SQL functions. Data dictionary views. SQL DDL statements handling tables (CREATE, ALTER, DROP, TRUNCATE). SQL DML statements (INSERT, DELETE, UPDATE, MERGE). SQL DCL statements (COMMIT, ROLLBACK, SAVEPOINT, GRANT, REVOKE). Using other database objects.

Compulsory/Recommended Readings:
- Ramez Elmasri, Shamkant B. Navathe: Fundamentals of Database Systems (7th Edition), Pearson, 2015.
- Viescas, Hernandez: SQL Queries for Mere Mortals, Addison-Wesley Professional, 2014.

NETWORK ARCHITECTURES AND PROTOCOLS

INBPA0210-17

Semester: 2
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: INBPA0104-21 (Introduction to programming) and INBPA0105-21 (Operating systems)
Responsible: Dr. Szabolcs Szilágyi

Topics:
Basic notions, history of the data networks, classification of the networks. Layered architecture, network reference models (OSI, TCP/IP, hybrid), intermediate network nodes. Elements and characteristics of the physical layer. Signal coding and modulation technics. Data network topologies.
Elements and characteristics of the data link layer. Mechanisms of the MAC sublayer. Static and dynamic channel access: FDM, TDM, ALOHA, slotted ALOHA, CDMA. LAN communication technologies: Ethernet (IEEE 802.3), token ring (IEEE 802.5). WAN communication technologies: SLIP, PPP, ISDN, ATM, DSL. IP network protocol: structure of the datagram, addressing system (classes, VLSM, CIDR), datagram switching. Dual addressing mechanisms: ARP, RARP, BOOTP, DHCP. IP address translation mechanisms: NAT, PAT. IPv6 addressing. Static and dynamic routing: DV, RIPv1, RIPv2, IGRP, EIGRP, Link-state routing, Dijkstra algorithm, IS-IS, OSPF, Inter-Area OSPF, DR, ABR functions. Transport layer protocols: segment structures of the UDP and TCP. TCP link management. Application layer protocols: DNS, FTP, TELNET, HTTP, SMTP, NTP, SNMP, RMON.

Compulsory/Recommended Readings:
- A. S. Tanenbaum, D. J. Wetherall: Computer Networks, 5th edition, Pearson, 2011.
- James F Kurose; Keith W Ross: Computer networking: a top-down approach, Pearson, 2017.

HIGH-LEVEL PROGRAMMING LANGUAGES 1

INBPA0211-21

Semester: 2
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: INBPA0104-21 (Introduction to programming)
Responsible: Dr. László Szathmáry

Topics:
The main goal of this course is to introduce basic programming concepts and tools with the use of a programming language that supports imperative programming. By the end of the semester, the students will be able to plan and implement simple programs, to read complex source codes and to proceed into an advanced course of programming.
The course covers the following basic programming tools. Compiler and interpreter. Variables, constants. Local and global variables. Scopes, lifetime. Control statements. Types, operators, operands. I/O tools. Functions, evaluation and pass-by techniques. Recursion, function call. Using the memory. Error handling; syntax and semantic errors. Command line arguments. Using libraries. Some thoughts will be given about basic computer science topics like Neumann-architecture, number systems, programming paradigms and history of programming languages.
The secondary aim of this course is to give an introduction into the tools and foundations of object oriented programming. The topics covered are: classes, objects, instantiation, constructors. Data and function members, inheritance, class hierarchies.

Compulsory/Recommended Readings:
- Brian W. Kernighan, Dennis M. Ritchie: The C Programming Language (2nd ed.). Englewood Cliffs, NJ: Prentice Hall, 1988
- Bjarne Stroustrup: The C++ Programming Language (4th edition), Addison-Wesley, 2013
- Kathy Sierra, Bert Bates: Head First Java (2nd ed.), O'Reilly, 2009
- Allen B. Downey: Think Python (How to Think Like a Computer Scientist), O'Reilly, 2012

HIGH-LEVEL PROGRAMMING LANGUAGES 2

INBPA0315-21

Semester: 3
Type: Seminar / Laboratory
Number of Classes: 0+2+2
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: INBPA0211-21 (High-level programming languages 1)
Responsible: Dr. László Szathmáry

Topics:
The main goal of this course is to give detailed insight into the tools of object oriented programming with the use of an object oriented programming language. By the end of the semester, the students will be able to write simple programs following the object oriented paradigm. The following topics will be covered: Data members and function members. Data hiding. Static methods and members. Inheritance, class hierarchies. Function overloading, polymorphism, overriding. Abstract classes, abstract methods. Packages, namespaces. Interfaces. Type conversions. Built-in types and reference types. Exceptions, exception handling.
The secondary aim of this course is to provide insights into the basics of functional programming tools (lambda expressions, e.g. streams), parallel programming and the programming of graphical user interfaces.

Compulsory/Recommended Readings:
- Bjarne Stroustrup: The C++ Programming Language (4th ed.), Addison-Wesley, 2013
- Herbert Schildt. Java: A Beginner's Guide (8th ed.), McGraw-Hill Education, 2018
- Y. Daniel Liang: Introduction to Java Programming and Data Structures (11th ed.), Pearson, 2017
- RB Whitaker: The C# Player's Guide (3rd ed.), Starbound, 2016
- Allen B. Downey: Think Python (How to Think Like a Computer Scientist), O'Reilly, 2012

WEB TECHNOLOGIES

INBPA0316-17

Semester: 3
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: INBPA0104-21 (Introduction to programming)
Responsible: Dr. Péter Jeszenszky

Topics:
The class introduces the basic concepts, architecture, standards, data formats (XML, JSON) and the operation (URI, HTTP) of the web. The HTML markup language, style-sheet languages (e.g., CSS, Less, Sass, Stylus), JavaScript, JQuery and the basics of responsive web design are also presented.

Compulsory/Recommended Readings:
- Ethan Brown. Learning JavaScript: JavaScript Essentials for Modern Application Development. O'Reilly Media, 2016.
- Adam Freeman. The Definitive Guide to HTML5. Apress, 2011.
- Peter Gasston. The Book of CSS3: A Developer's Guide to the Future of Web Design. 2nd ed. No Starch Press, 2014.
- Ilya Grigorik. High Performance Browser Networking: What every web developer should know about networking and web performance. O'Reilly Media, 2013.
- Peter Gasston. The Modern Web: Multi-Device Web Development with HTML5, CSS3, and JavaScript. No Starch Press, 2013.

SOFTWARE ENGINEERING AND TECHNOLOGIES

INBPA0420-21

Semester: 4
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: INBPA0315-21 (High-level programming languages 2)
Responsible: Dr. Péter Jeszenszky

Topics:
The main goal of the course is to communicate knowledge required for designing and creating quality software, and also to introduce students with developer tools used widely in industrial software projects. The course covers the following major topics:

- Foundations of object oriented design, UML
- Patterns in software development, architectural patterns, design patterns
- Principles of object-oriented programming
- Clean code, code refactoring
- Software testing, test-driven development
- Software quality, software measurement, software metrics
- Software licenses, free and open source software

The following topics are discussed with the use of industry standard developer tools:

- Advanced version control, e.g., working with branches, workflows for team work (Git)
- Build automation and project management (e.g.,Maven, Gradle)
- Issue tracking (e.g., GitHub Issues, Jira, Trello)
- Continuous integration, continuous deployment, continuous delivery (e.g., GitHub Actions, Jenkins)

Compulsory/Recommended Readings:
• Ian Sommerville. *Software Engineering*. 10th ed. Pearson Education, 2015. http://iansommerville.com/software-engineering-book/
• David Thomas, Andrew Hunt. *The Pragmatic Programmer, 20th Anniversary Edition*. 2nd ed. Addison-Wesley Professional, 2019. https://pragprog.com/titles/tpp20/the-pragmatic-programmer-20th-anniversary-edition/
• Martin Fowler. *Refactoring: Improving the Design of Existing Code*. 2nd ed. Addison-Wesley Professional, 2018. https://martinfowler.com/books/refactoring.html
• Robert C. Martin. *Clean Code: A Handbook of Agile Software Craftsmanship*. Prentice Hall, 2008
• Scott Chacon, Ben Straub. *Pro Git*. 2nd edition. Apress, 2014. https://git-scm.com/book/en/v2

SOFTWARE DEVELOPMENT METHODOLOGIES

INBPA0521-17

Semester: 5
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Obligatory
Assessment: Practical mark
Prerequisites: INBPA0211-21 (High-level programming languages 1)
Responsible: Dr. Attila Tamás Adamkó

Topics:
The aim of the subject is to introduce the software development process, software engineering methods (traditional, agile) and the tools and processes of software engineering.

Compulsory/Recommended Readings:
- Ian Sommerville: Software Engineering, Pearson Education, 10th edition, 2015
- Kenneth S. Rubin: Essential Scrum: A Practical Guide to the Most Popular Agile Process (Addison-Wesley Signature Series (Cohn)),
- Klaus Pohl, Chris Rupp: Requirements Engineering Fundamentals, Rocky Nook Inc.2015
- Lisa Crispin, Janet Gregory: Agile Testing: A Practical Guide for Testers and Agile Teams, Addison-Wesley Professional, 2009
- Andrew Stellman, Jennifer Greene: Learning Agile: Understanding Scrum, XP, Lean, and Kanban, 2014.

WEB APPLICATION DEVELOPMENT

INBPA0522-21

Semester:	5
Type:	Seminar / Laboratory
Number of Classes:	0+2+2
Credit:	6
Status:	Obligatory
Assessment:	Practical mark
Prerequisites:	INBPA0315-21 (High-level programming languages 2) and INBPA0316-17 (Web technologies)
Responsible:	Dr. Zoltán Attila Godó

Topics:
In the class the students are introduced to the tools and processes of the development of web applications through the presentation and practice of technologies widely applied in the industry.

Compulsory/Recommended Readings:
- Jason Hunter, William Crawford: Java Servlet Programming, O'Reilly Media, 2011
- Joel Murach & Michael Urban: Murach's Java Servlets and JSP, Mike Murach & Associates, 2014
- Craig Walls: Spring in Action, Manning, 2014
- Bill Burke: RESTful Java with JAX-RS 2.0, O'Reilly Media, 2009
- Spring Framework Reference Documentation, 2016

Differentiated Knowledges

3D PRINTING AND MODELING

INBPA9924-17

Semester: 2
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0103-17 (Computer aided mathematics and visualization)
Responsible: Dr. Ildikó Papp

Topics:
The goal of this subject is to acquaint the students with the basic concepts of 3D printing and modeling, applicability of additive manufacturing in the industrial environment, through illustrative examples and practices. Related topics: Introduction from CAD to CAM, Fundamentals of 3D printing, FDM and other technologies, Preparing models to 3D printing, Fundamentals of 3D modeling, Advanced modeling techniques: parametric modeling, script-based and mesh based design, 3D scanning in model building, Applications of 3D printing (industry, healtcare, research etc.).

Compulsory/Recommended Readings:
- M. Amundsen, E. Arden, D. Lentz, P. Lyttle, L. Taalman: MakerBot in The Classroom, An Introduction to 3D Printing and Design, MakerBot Publishing, Brooklyn, NY, 2015. ISBN:9781495161759.
- Matt Lombard: SolidWorks 2010 Bible, Wiley Publishing Inc., 2010. Indianapolis
- ISBN: 978-047055481.
- Al Williams: OpenSCAD for 3D Printing, CreateSpace Independent Publishing Platform, 2014, ISBN: 1500582476.

CLOUD COMPUTING

INBPA9925-17

Semester: 2
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0105-21 (Operating systems)
Responsible: Dr. Tamás Márton Bérczes

Topics:
The goal of the subject is to provide an introduction to cloud computing (C2) topics, especially the software development in the cloud computing methods. Students will learn about cloud com-puting (C2) system and foundations. Get acquainted with the functioning of the Clouds, pro-gramming methods, as well as the management of common problems in the development.

Compulsory/Recommended Readings:
- Rajkumar Buyya: Cloud Computing Principles and Paradigms, Wiley, 2011.
- Roger Jennings: Cloud Computing with the Windows Azure Platform, Wrox, 2009.
- Jurg van Vliet, Flavia Paganelli: Programming Amazon EC2, O'Reilly Media, 2011.
- James Beswick: Google Apps Express: The Fast Way To Start Working in the Cloud, CreateSpace, 2011.

BASICS OF GIS

INBPA9926-17

Semester: 2
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0103-17 (Computer aided mathematics and visualization)
Responsible: Dr. Marianna Zichar, Bodroginé

Topics:
Representing, editing, handling, and analyzing vector and raster data using a geographic information system (styling, scale dependent visibility, automated update, classification, etc.). Projections, measuring, planning and performing network analysis. Publishing geospatial data on the web, special data formats. Applications of 3D models in GIS. Case studies.

Compulsory/Recommended Readings:
- Longley, Paul A. and Goodchild, M. F.: Geographic Information Science and Systems, Wiley, 2015, 978-1118676950
- Fu, P. and Sun J.: Web GIS, Principles and applications, ESRI Press, 2011. 978-1589482456

GRAPHICS SYSTEMS

INBPA9944-17

Semester: 2
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0103-17 (Computer aided mathematics and visualization)
Responsible: Dr. Henrietta Tomán

Topics:
Students learn about two- and three-dimensional procedural modeling, texturing, lighting, rigging, animation and rendering techniques, the most important properties of object hierarchy, applying geometric transformations, particle systems, physical simulations. Parallelly, parametrization of the models and the discussed methods, basics of scripting, developing and testing of automated solutions are introduced, as well.
The objective of the course: to deepen the knowledge of the students in the field of computer graphics and programming, to become familiar with an open-source 2D-3D graphical modeling and animator software solution.

Compulsory/Recommended Readings:
- J. Hughes, A. van Dam, M. McGuire, D. Sklar, J. Foley, S. Feiner, K. Akeley: Computer
- Graphics: Principles and Ptactice, Addison-Wesley Professional; 3rd edition, 2018.
- M. Chandramouli: 3D Modeling & Animation: A Primer, CRC Press; 1st edition, 2021.
- A. Beane: 3D Animation Essentials, Sybex; 1st edition, 2012.

BIOINFORMATICS

INBPA9927-17

Semester: 3
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0206-17 (Data structures and algorithms)
Responsible: Dr. Zoltán Attila Godó

Topics:
Learning opportunities for the application of information technology in the field of life sciences. Issues, problems and their solutions to biological information processing. Developing special IT approach, due to the nature of biological field of study.

Compulsory/Recommended Readings:
- Hassanien, Aboul Ella, Taher Azar, Ahmad (Eds.): Brain-Computer Interfaces, Current Trends and Applications. Springer, 2015.
- N.C. Jones, A. Pavel, A. Pevzner: An Introduction to Bioinformatics Algorithms, MIT Press, 2004.
- P. Baldi, S. Brunak, S. Brunak: Bioinformatics: The Machine Learning Approach, S.E. (Adaptive Computation and Machine Learning), MIT Press, 1998.
- S. Letovsky: Bioinformatics: Databases and Systems, Springer-Verlag, 1999.
- Stephen Hawking, Leonard Mlodinow: The Grand Design, Hardcover, 2010.

E-SPORT

INBPA9928-21

Semester: 3
Type: Lecture
Number of Classes: 2+0+0
Credit: 3
Status: Optional
Assessment: Exam
Prerequisites: INBPA0211-21 (High-level programming languages 1)
Responsible: Renátó Besenczi

Topics:
The goal of subject is to familiarize students with the world of e-sports. The topics are the followings. History of electronic games and the video game culture, 1337 cipher case study. Gaming industry, business models. Electronic game genres. MMOG, RPG, FPS, RTS and MOBA. Social/casual, mobile and competitive gaming. Linux gaming. Open source games. E-sports. Tiers of competitive gaming. Live event case studies (organized play with classmates). E-sports shoutcasting. E-sports spectating. Game broadcasting, streaming case study (OBS streaming to Twitch). E-sports communities. Organizing e-sports tournaments, organizing case study. Games and AI, AI and games case studies. E-sport analytics.

Compulsory/Recommended Readings:
- T. L. Taylor (2012) Raising the Stakes: E-Sports and the Professionalization of Computer Gaming. The MIT Press.
- Juho Kuorikoski (2015) Finnish Video Games: A History and Catalog. McFarland.
- Dal Yong Jin (2010) Korea's Online Gaming Empire. The MIT Press.

OPERATION OF INFOCOMMUNICATION SYSTEMS

INBPA9929-17

Semester: 3
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0210-17 (Network architectures and protocols)
Responsible: Dr. Szabolcs Szilágyi

Topics:
Explore the corporate networks. Network devices. Configure the network operating system. Physical layer. Twisted-pair communication standards, termination and testing tasks. Data Link layer. Ethernet. Network layer. IP configuration. IP subnetting. Transport layer. UDP. T•CP. Application layer. Introduction to switched networks. Basic switching concepts and configuration. VLANs. Inter-VLAN routing. Static and dynamic routing (RIP). Single-area OSPF. Standard and extended access control lists. DHCP. Network Address Translation for IPv4 (NAT). LAN design problems (exercises).

Compulsory/Recommended Readings:
- Wendell, Odom: CCENT/CCNA ICND1 100-105 Official Cert Guide, Cisco Press, 2016, ISBN: 978-1-58720-580-4.
- Scott, Empson: CCNA Routing and Switching Portable Command Guide, 4th Edition, Cisco Press, 2016, ISBN: 978-1-58720-588-0.

IMAGE PROCESSING IN PRACTICE

INBPA9930-17

Semester: 3
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0211-21 (High-level programming languages 1)
Responsible: Dr. Szilvia Szeghalmy

Topics:
Overview of an image processing library. Basic structures. Loading, writing and displaying images. Working with video streams. Colour spaces, colour space conversions. Enhancement methods in spatial and frequency domain. Common morphological operators. Edge detectors. Image segmentation. Object detection/recognition using classifiers. Case studies.

Compulsory/Recommended Readings:
- Kaehler, A., Bradski, G.: Learning OpenCV 3, O'Reilly Media, 2016, Ebook ISBN:978-1-4919-3794-5
- Laganiere, R.: OpenCV 3 Computer Vision Application Programming Cookbook, 3rd ed., Packt Publishing, 2017, ISBN: 978-1-78646-971-7
- Gonzales, R.C., Woods, R.E.: Digital image processing, 3rd ed. Prentice-Hall, Inc., 2008. ISBN-13: 978-0131687288.

HIGH-LEVEL PROGRAMMING LANGUAGES 3

INBPA9931-17

Semester: 3
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0211-21 (High-level programming languages 1)
Responsible: Dr. János Pánovics

Topics:
The basics of the functional programming paradigm (recursion, statelessness, referential transparency, function as value). General properties of languages implementing the elements of the functional programming paradigm (LISP, CLOS, ML, Scala, F#, Haskell, Clojure). Type systems in functional languages. Higher-order functions. Expressions. List handling. Tail recursion. Partial function application (currying). Function composition. Closure. Memoization. Pattern matching, evaluation strategies (lazy, eager). Functional data structures. Functional design patterns. Monoids, monads. Parallel and concurrent programming. Programming in multiparadigm languages.

Compulsory/Recommended Readings:
- Paul Chiusano, Rúnar Bjarnason: Functional Programming in Scala, Manning, 2014, ISBN-13: 978-1617290657.
- Tomas Petricek, Jon Skeet: Real-World Functional Programming: With Examples in F# and C#, Manning, 2010, ISBN-13: 978-1933988924.
- Chris Smith: Programming F# 3.0, 2nd edition, O'Reilly, 2012, ISBN-13: 978-1449320294.

SCRIPTING LANGUAGES

INBPA9942-17

Semester: 3
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0211-21 (High-level programming languages 1)
Responsible: Dr. László Szathmáry

Topics:
Features of scripting languages. Classification of scripting languages. Fundamental data structures of scripting languages: string, dynamic array, associative array. Advanced string handling, regular expressions. Writing command-line applications. Replacing Bash scripts with higher level scripting languages. Connection with the operating system. Mixing procedural and object-oriented approaches. Functional and parallel programming in scripting languages. Connecting to databases. Writing simple graphical user interfaces (GUIs). Writing web applications with scripting languages.
After this course, students will be able to implement simple programs in a modern scripting language.

Compulsory/Recommended Readings:
- Guido van Rossum: Python Tutorial, 2020
- Brian d Foy, Tom Christiansen, et al.: Programming Perl, O'Reilly, 2012
- David Flanagan, Yukihiro Matsumoto: The Ruby Programming Language, O'Reilly, 2008

INTRODUCTION TO 3D GAME DEVELOPMENT

INBPA9932-17

Semester:	4
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0103-17 (Computer aided mathematics and visualization) and INBPA0315-21 (High-level programming languages 2)
Responsible:	Dr. Kinga Tünde Kruppa

Topics:
Introduction, game design principles, the most commonly used game engines and development platforms. The possibilities of the used game engine. Some key concepts from computer graphics, transformations, projections, animations, material properties, lighting, camera. Tools and software for using effects, sounds and models. Camera and scene settings. Physics models for describing movements, animations. Controlling objects. Graphical user interface. Scripts. Particle systems. Implementing the mentioned topics separately and all together through examples.

Compulsory/Recommended Readings:

• Vahe Karamian: Introduction to Game Programming: Using C# and Unity 3D, Noorcon Inc., 2016. ISBN: 978-0997148404
• Fletcher Dunn, Ian Parberry: 3D Math Primer for Graphics and Game Development (2nd Edition), A K Peters/CRC Press, 2011, ISBN: 978-1568817231
• Jesse Schell: The Art of Game Design: A Book of Lenses (2nd Edition), A K Peters/CRC Press, 2014, ISBN: 978-1466598645
• Geremy Gibson Bond: Introduction to Game Design, Prototyping, and Development: From Concept to Playable Game with Unity and C# (1st Edition), Addison-Wesley Professional, 2014, ISBN: 978-0321933164
• Katie Salen Tekinbaş, Eric Zimmerman: Rules of Play: Game Design Fundamentals, The MIT Press, 2003, ISBN: 978-0262240451

COMPILERS

INBPA9933-17

Semester:	4
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0211-21 (High-level programming languages 1) and INBPA0314-21 (Introduction to computer science)
Responsible:	Dr. Géza Horváth

Topics:
Structure of the compilers, reader, extender, grammars, parsing, syntax tree, domain specific languages, source-source compilers, interpreters.

Compulsory/Recommended Readings:
- Matthew Butterick: Beautiful Racket 2017.
- Torben Aegidius Mogersen: Basics of Compiler Design 2010.

MACHINE LEARNING IN PRACTICE

INBPA9934-17

Semester:	4
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0211-21 (High-level programming languages 1) and INBPA0313-17 (Applied statistics)
Responsible:	Dr. Márton Ispány

Topics:
Mathematical foundations and basic Python skills. Overview of Python ecosystem. Scientific Python distributions (Anaconda) IDE: IPython, Jupyter notebooks. Numpy, Scipy, MatPlotLib. A machine learning toolbox. Data reading and preprocessing. Dimension reduction and data visualization. Classification. Model selection. Application of classification: spam-filtering, image processing. Regression. Clustering. Clustering performance evaluation. Clustering applications: vector quantization, image segmentation, customer segmentation, text processing.

Compulsory/Recommended Readings:
- A. C. Müller, S. Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists. O'Reilly Media, 2016.
- S. Raschka, Python Machine Learning. Packt Publishing Ltd. 2015.

ADVANCED DATABASE KNOWLEDGE

INBPA9935-17

Semester: 4
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0209-17 (Database systems lab)
Responsible: Dr. Anikó Szilvia Vágner

Topics:
Getting acquainted with the structure (memory, storage, background processes) of the selected database management system (like Oracle), designing relational databases, creating and using advanced database objects, tuning techniques.

Compulsory/Recommended Readings:
- Mullins: Database Administration, Addison-Wesley, 2013
- Ramez Elmasri, Shamkant B. Navathe: Fundamentals of Database Systems, Pearson, 2015.

NOSQL DATABASES

INBPA9936-17

Semester:	4
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0209-17 (Database systems lab) and INBPA0315-21 (High-level programming languages 2)
Responsible:	Dr. Anikó Szilvia Vágner

Topics:
The emergence of NoSQL databases, types of NoSQL databases (like graph, key-value, document, column-family), distributed models, consistency, feautes of each types of databases, case studies, creating the data structure, insert, update, delete data, query data, realization of distributed models, Map-reduce, developing a simple application.

Compulsory/Recommended Readings:
- NoSQL: Sadalage és Fowler: NoSQL Distilled, Addison-Wesley, 2013.
- NoSQL: Sulliva: NoSQL for Mere Mortals, Addison-Wesley, 2015.

FUNDAMENTALS OF INFORMATION AND CODING THEORY

INBPA9943-17

Semester: 4
Type: Lecture
Number of Classes: 2+0+0
Credit: 3
Status: Optional
Assessment: Exam
Prerequisites: INBPA0313-17 (Applied statistics)
Responsible: Dr. Sándor Baran

Topics:
General scheme of telecommunication systems. Fundamentals of source coding (uniquely decipherable and prefix codes, efficiency, basic encoding algorithms). Universal source coding, Lempel-Ziv algorithms. Measure of information, entropy, conditional entropy, mutual information and their properties. Channel capacity. Search strategies. Encoding of general information sources, block encoding. Differential entropy. Fundamentals of error correcting coding. Linear codes.

Compulsory/Recommended Readings:
- Cover, Thomas M. and Thomas, Joy A.: Elements of Information Theory. Wiley, 2006.
- Togneri, Roberto and de Silva, Christopher J. S.: Fundamentals of Information Theory and Coding Design. Chapman & Hall/CRC, 2006.
- Ash, Robert B.: Information Theory. Dover Publications, 1990.

MOBILE APPLICATION DEVELOPMENT

INBPA9937-17

Semester: 5
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0420-21 (Software engineering and technologies)
Responsible: Máté Szabó

Topics:
The aim of the subject is to introduce a mobile platform and the basics of mobile application development for the students.

Compulsory/Recommended Readings:
- Kyle Mew: Android 5 Programming by Example, Packt Publishing, 2015.
- Hoc Phan: Ionic 2 Cookbook, Packt Publishing, 2016.
- Nathanael J. Anderson: Getting Started with NativeScript, Packt Publishing, 2016.
- Dan Hermes: Xamarin Mobile Application Development: Cross-Platform C# and Xamarin. Forms Fundamentals, Apress, 2015.

COMPUTER STATISTICS

INBPA9938-17

Semester: 5
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0313-17 (Applied statistics)
Responsible: Dr. Kinga Sikolya-Kertész

Topics:
Solution of statistical problems, statistical data analysis, describing of database with the help of a statistical software.

Compulsory/Recommended Readings:
- Montgomery, D. C. and Runger, G. C.: Applied Statistics and Probability for Engineers, Wiley, 2010.
- P. Dalgaard: Introductory Statistics with R. Springer, 2008.
- Everitt, B.S., Hothorn, T.: A Handbook of Statistical Analysis Using R, Chapman & Hall, 2014.

SOFTWARE TESTING

INBPA9939-17

Semester: 5
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0420-21 (Software engineering and technologies)
Responsible: Dr. Gergely Kocsis

Topics:
By this class the student are introduced to software testing, especially test automation and to the role of these topics. The students will know their place in the system development process and will be able to contribute in them. They will understand the methods and will be able to apply them.

Compulsory/Recommended Readings:
- Agile Testing: A Practical Guide for Testers and Agile Team, Addison-Wesley Professional, 2009.
- Matt Wynne, Aslak Hellesøy: The Cucumber Book, Behaviour-Driven Development for Testers and Developers, Pragmatic Bookshelf, 2012.
- Bayo Erinle: Performance Testing with Jmeter, Packt Publishing, 2015.
- Greg Paskal: Test Automation in the Real World: Practical Lessons for Automated Testing, Independently published, 2017

ADVANCED DATA SECURITY

INBPA9940-17

Semester:	6
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0419-17 (Foundations of computer security) and INBPA0522-21 (Web application development)
Responsible:	Dr. Csanád Bertók

Topics:
Wireshark network packet analyzer, Problems of web server configuration, Web server authentication, SSL certificates, Web application security, The OpenSSL cryptographic library: Digital signatures, Encrypting files, Secure communication.

Compulsory/Recommended Readings:
- Dafydd Stuttard, Marcus Pinto: The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws, 2nd Edition, Wiley, 2011, ISBN: 978-1-118-02647-2.
- Ivan Ristić: OpenSSL Cookbook, Second Edition, Feisty Duck, London, 2015.

ADVANCED WEB TECHNOLOGIES

INBPA9941-17

Semester: 6
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0522-21 (Web application development)
Responsible: Dr. Attila Tamás Adamkó

Topics:
In the class the students are introduced to the tools and processes of the development of web applications through the presentation and practice of technologies widely applied in the industry, especially front-end web application frameworks.

Compulsory/Recommended Readings:
- Ethan Brown: Learning JavaScript: JavaScript Essentials for Modern Application Development. O'Reilly Media, 2016.
- Asim Hussain: Angular 4: From Theory To Practice: Build the web applications of tomorrow using the new Angular web framework from Google, CodeCraft, 2017.
- Nathan Rozentals: Mastering TypeScript, Packt Publishing, 2017.
- Shelley Powers: Learning Node: Moving to the Server-Side, O'Reilly Media, 2016.

VIRTUAL REALITY AND ITS APPLICATIONS

INBPA9949-17

Semester:
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0103-17 (Computer aided mathematics and visualization)
Responsible: Dr. Attila László Gilányi

Topics:
General properties of virtual, augmented and mixed reality; virtual space, virtual environment; virtual reality devices and their use; display of virtual spaces; presentation of information, preparing presentations; the basics of three-dimensional modeling and animation, creating objects, adding physical properties to them, and embedding them in virtual spaces; three-dimensional modeling and animation systems; basic human factors related to virtual reality: potential health problems, ethical issues, the right way to create and use virtual spaces; application of virtual reality in education, engineering, medicine, architecture, corporate governance, military, historical studies, archeology and other fields.

Compulsory/Recommended Readings:
- Steven M. LaValle, Virtual Reality, Cambridge University Press, 2017.
- Tony Parisi, Learning Virtual Reality, O'Reilly Media, 2015. ISBN: 978-1-4919-2283-5.
- Jerald, Jason: The VR Book: Human-Centered Design for Virtual Reality, ACM Books, Morgan & Claypool Publishers, 2015. ISBN: 978-1-97000-112-9.

ETHICAL HACKING I.

INBPA9950-17

Semester:
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0211-21 (High-level programming languages 1)
Responsible: Dr. Csanád Bertók

Topics:
Advanced Linux management: BASH scripting, pipes. Basic principles and tools: bind shell, reverse shell, SSH, netcat, socat, msfvenom. Active information gathering: nmap. Vulnerability scanning and exploit databases: exploit-DG, gtfobins, searchsploit. Buffer overflow attacks: Immunity Debugger, gdb, SUID bits. Automatic and semi-automatic tools: Nessus, LinPEAS, WinPEAS, Metasploit, Nikto.
Hash and password online and offline attacks: hashcat, john the ripper, THC hydra, wpscan, Burp Suite.
Network analysis and exploitation: Wireshark, aircrack-ng, dirbuster, gobuster.

Compulsory/Recommended Readings:

- ·Ric Messier – CEH v10 Certified Ethical Hacker Study Guide, ISBN-13: 978-1119533191
- ·Peter Kim – The Hacker Playbook (1,2,3): Practical Guide to Penetration Testing

BLOCKHAIN TECHNOLOGY

INBPA9951-17

Semester:
Type: Lecture
Number of Classes: 2+0+0
Credit: 3
Status: Optional
Assessment: Exam
Prerequisites: None
Responsible: Dr. Andrea Pintér-Huszti

Topics:
The primary aim of the course is to help students learn the basics of blockchain technology.

Week 1: Introduction to the basics of the blockchain - the history of the blockchain, the properties of the blockchain, the CAP theorem, the problem of Byzantine generals
Week 2: The cryptographic background of the blockchain - hash functions
Week 3: Blockchain structure and operation
Week 4: Blockchain transactions
Week 5: Blockchain consensus mechanisms
Week 6: Blockchain related applications - cryptocurrencies
Week 7: Blockchain related applications - contracts
Week 8: Technical challenges of the blockchain, suggestions and improvements
Week 9: Case studies: Ripple, WeTrade, Santander, Lo3 energy, Smartresume
Week 10: Blockchain-based applications
Week 11: The future of blockchains
Week 12: End-term Test

Compulsory/Recommended Readings:

- Nakamoto, Satoshi. "Re: Bitcoin P2P e-cash paper." The Cryptography Mailing List (2008).
- Swan, Melanie. Blockchain: Blueprint for a new economy. " O'Reilly Media, Inc.", 2015.
- Lacity, Mary C. Blockchain foundations: for the internet of value. Epic Books, 2020.

INTRODUCTION TO REINFORCEMENT LEARNING

INBPA9955-17

Semester:
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: None
Responsible: Gergő Bogacsovics

Topics:
By completing this course, students will learn about reinforcement learning (RL), its various applications and will also gain the minimum theoretical background of algorithms needed to solve real-world problems. Students will acquire knowledge in the following areas: the history of RL, similarities and differences between traditional machine learning and RL, basic concepts of RL (reward, exploration, exploitation, etc.), difficulties of RL, classic RL algorithms (Q-learning), deep learning-based RL algorithms (deep Q-learning, PPO, etc.). The algorithms presented in this course will be used in a variety of interactive, realistic environments (e.g. OpenAI Gym and Unity ML-Agents), providing students with important hands-on experience in implementing, fine-tuning and debugging several unique environments.

Compulsory/Recommended Readings:
- Sutton, Richard S., and Andrew G. Barto. Reinforcement learning: An introduction. MIT press, 2018.
- Wiering, M., & Van Otterlo, M. (2012). Reinforcement learning. Adaptation, learning, and optimization, 12(3).
- Felicia, P. (2017). Unity From Zero to Proficiency (Foundations): A step-by-step guide to creating your first game with Unity (Vol. 1). Patrick Felicia.

INTRODUCTION TO THE AWS CLOUD

INBPA9958-17

Semester:
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Ádám Tóth

Topics:
In this course, students will learn the basic concepts of the AWS cloud; the AWS pricing philosophy; the global infrastructure components of AWS; and the security and compliance measures of the AWS cloud, including AWS identity and access management (IAM). You will learn how to build an AWS virtual private cloud; the use of Amazon Elastic Compute Cloud (EC2), AWS Lambda, and AWS Elastic Beanstalk; the differences between Amazon S3, Amazon EBS, Amazon EFS, and Amazon S3 Glacier; and the use of AWS database services (Amazon Relational Database Service (RDS), Amazon DynamoDB, Amazon Redshift, and Amazon Aurora). Students learn the principles of the AWS Cloud architecture and key concepts related to elastic load balancing (ELB), Amazon CloudWatch and auto scaling.
This course helps prepare students for the AWS Cloud Practitioner certification exam.

Compulsory/Recommended Readings:
- https://docs.aws.amazon.com/
- https://aws.amazon.com/whitepapers/
- https://d0.awsstatic.com/whitepapers/aws-overview.pdf
- https://d1.awsstatic.com/whitepapers/AWS_Cloud_Best_Practices.pdf
- https://d0.awsstatic.com/whitepapers/aws_pricing_overview.pdf
- https://media.amazonwebservices.com/AWS_TCO_Web_Applications.pdf

NETWORK AND SYSTEM SECURITY

INBPA9959-21

Semester:
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0105-21 (Operating systems)
Responsible: Dr. Csanád Bertók

Topics:
Description of blue teaming, basic tasks, objectives, tools. Demonstartion of virtualization techniques (Hypervisors, LXC, VM). Creating a virtual environment packed with typical blue teaming tools: firewalls, routers, load balancing. Demonstration of frequent host-based firewall settings, port forwarding. Basic concepts and creation of DMZ. Deployment of reverse proxy, VPN, Radius server. Deployment of different HIDS, NIDS and other monitoring tools: SNMP and Agent-based monitoring. Creation of SSH Bastion hosts, limiting access. Basics of permissions, logging and log evaluation.

Compulsory/Recommended Readings:
- Don Murdoch: Blue Team Handbook: SOC, SIEM, and Threat Hunting (V1.02): A Condensed Guide for the Security Operations Team and Threat Hunter
- Alan White & Ben Clark: Blue Team Field Manual (BTFM) (RTFM)